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Synthesis and Characterisation of Thin Films using *Tanner's Cassia*, *Nerium*, Basil Leaf Extract Doped with Green Tea Extract Deposited by Single Dip Coating Method

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Abstract

In order to replace the rare and expensive inorganic and organic elements, we preferred plant extract which is very cost effective and eco-friendly and thus can be economic and effective alternative for the large scale synthesis. Herein we report for the first time, the synthesis and characterisation of thin films by using Green Tea, Tanner's cassia, Nerium oleander and Basil leaf extracts were investigated. The extracts were deposited by using dip coating method at 70 ^{o}C on glass substrates. The structural and optical properties of the samples were investigated by using XRD and UV-Vis absorption spectroscopy. The effect of the different solvents on the particle size was analysed by using XRD. Band gap energy and other optical constants of thin films were calculated by using UV-Vis absorption spectroscopy. High transmission properties of the prepared samples were proved by using UV-Vis absorption spectroscopy. Also visible photoluminescence (PL) emissions from the synthesized thin films were recorded. The elemental compositions of the samples were analysed by using energy dispersive X-ray analysis (EDAX).

Keywords: *Dip coating; Green tea and leaf extract; Nerium; Tanner's Cassia.*

1. INTRODUCTION

Generally, the plants contain a broad range of bioactive compounds such as lipids, phytochemicals, pharmaceutics, flavors, fragrances and pigments. Plant extracts are widely used in the food, pharmaceutical and cosmetics industries. Extraction techniques have been widely used to obtain such valuable natural compounds from plants for commercialization. The use of environmentally benign materials like plant extract for the preparation of thin film can offer numerous benefits of eco-friendliness, cost effective and easily available and scaled up for large scale synthesis.

Several methods have already proposed in the literature for the preparation of thin film. However, dip-coating is a very simple technique to deposit a thin film from a various precursors. In this process, a specified substrate is dipped in a uniform solution, after that it is withdrawn from the solution and dried the substrate. The dip-coating methods are frequently employed to produce thin films from various precursors for research purposes, where it is generally used for applying films onto flat or cylindrical substrates (Maissel and Clang, 1970; Bunshah, 1982; Vossen and Kern, 1978). The structural property of the thin film is very important since it can give an explanation for the behavior of the optical properties of the thin films.

In the present study, the synthesis and characterisation of thin films from plants extract with varying sizes using Green Tea, *Tanner's cassia*, *Nerium oleander* and *Basil leaf* extracts were investigated and the plants extract was deposited by using dip coating method at 70 ^{o}C on glass substrates. The structural and optical properties of the prepared samples were investigated by using XRD, UV-Visible, photoluminescence (PL) and EDAX analysis.

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2. MATERIALS & METHODS

2.1 Preparation of Plants Extract

Fresh plants of Green Tea, *Tanner's cassia, Nerium, Basil* were identified and collected. The leaves were collected and washed with distilled water to remove all the dust particles. After washing, the leaves were spread evenly in a clean paper and the leaves were allowed to dry in the shade for about 3-4 days. The leaves were dried completely and the dried leaves were finely powdered by using mixer and then it was used for extraction.

2.2 Sample Preparation

Sample 1-Green Tea powder (2 g) was mixed with 50 mL of distilled water and it was stirred and boiled at 70 ^{o}C for 30 mins. The mixture was brought to the room temperature and the aqueous leaf extract was collected by using filter paper.

Sample 2-About 1 g of each leaf powder samples (*Tanner's cassia, Nerium, Basil*) was mixed with 50 mL of distilled water and it was stirred and boiled at 70 ^{o}C for 30 mins. The mixture was brought to the room temperature and the aqueous leaf extract was collected by using filter paper.

Sample 3-*Tanner's cassia, Nerium, Basil* each (1 g) doped with Green Tea (2 g) were mixed with 50 mL of distilled water and it was stirred and boiled at 70 ^{o}C for 30 mins. The mixture was brought to the room temperature and the aqueous leaf extract was collected by using filter paper.

Sample 4-50 mL of polluted water was taken for the preparation of thin film sample.

Sample 5-2 g of Green Tea powder was mixed with 50 mL of polluted water and it was stirred for 1 hr without heating.

Sample 6-*Tanner's cassia, Nerium, Basil* each (1 g) were doped with Green Tea (2 g) mixed with 50 mL of polluted water and it was stirred for 1 hr without heating.

2.3 Materials Characterization

X-Ray Diffraction studies were carried out to determine the grain size, packing factor, dislocation density and micro strain. X-ray diffraction patterns of all the samples were taken in the range of 2θ between 5^{o} and 100^{o}. The absorption coefficient (α) of these thin films was determined by using a UV/Vis Spectrometer with wavelength range of 200-800 nm. The spectral data was used to determine the type of extinction co-efficient, refractive index, optical conductivity dielectric constant, imaginary dielectric constant and the band gap present in the samples. The thickness of the films was measured by using gravimetric method (AsraParveen *et al*. 2013). The elemental compositions of all the thin film samples were analysed by using Energy Dispersive X-Ray analysis (EDAX).

3. RESULT & DISCUSSION

3.1 XRD Analysis

3.1.1 Discussions on grain size

XRD patterns of all the samples are shown in fig. 1. The grain size of 0.358 nm was observed for pure Green Tea. While the calculated grain size of *Basil, Tanner's cassis and Nerium oleander* is around 0.275 nm. When *Basil, Tanner's cassis* and *Nerium oleander* extracts doped with Green tea extract (GTE), the grain size was increased as 0.372 nm. For pure Polluted Water, the grain size is around 0.306 nm. When pure green tea film is prepared with polluted water, the grain size of the film was (GTE film with polluted water) calculated and the grain size is around 0.355 nm. It was observed that grain size of thin film was increased due to the addition of GTE which added with polluted water (Udayasoorian *et al*. 2011). It can be concluded that when GTE was mixed with either pure distilled water (or) polluted water, the observed grain size is more or less same. When we prepared GTE thin film with polluted water in addition of *Tanner's cassis, Nerium oleander* and *Basil* extracts, the observed grain size was higher (i.e. 0.42 nm) as compared to other thin film samples (Priya Tharishini *et al*. 2014).

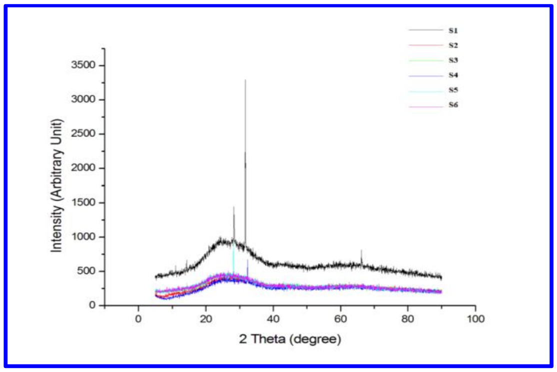

Fig. 1: Comparison of XRD patterns of all the thin film samples

3.1.2 Discussions on packing factor, micro strain and dislocation density

The parameters such as packing factor, micro strain and dislocation density were calculated and the values are mentioned in the table 1. In the present work, when we added dopant with the GTE, the grain size and packing factor were increased as compared with pure sample whether the solvent was used as distilled water or polluted water. Especially, when we used polluted water as solvent, the grain size and packing factor were drastically increased. When packing factor was increased, the dislocation density and micro strain were decreased (Senthil kumar and Sivakumar, 2014).

3.2 Optical studies

To study the optical properties of the thin films, the optical absorption spectrum of the film was recorded in the wavelength range of 200-800 nm (Udayasoorian *et al*. 2011; Priya Tharishini *et al*. 2014). The results of the optical studies are shown in the table 2. The extinction co-efficient, refractive index, optical conductivity dielectric constant, imaginary dielectric constant and the band gap were estimated by using UV-Vis spectroscopy as shown in fig. 2.

3.2.1. Optical band gap (E_g)

The energy band gap of all the thin film samples are depicted in fig. 3. In the present case, better linearity was observed and it confirmed that the thin film has a direct band transition (Senthil kumar and Sivakumar, 2014). By extrapolation the linear portion of the curve to photon energy axis for zero absorption coefficient, the intercept of the curve shows the optical band gap of six prepared thin films which were estimated to be 3.9 to 4.0 eV (Velavan *et al*. 2013).

3.3 Energy dispersive x-ray analysis (EDAX)

The elemental composition of all the samples were analysed by using EDAX. Table 3 shows comparison of EDAX results of all the thin film samples. The presence of Mg, Na, K, Ca, Al and P elements in all the thin films was confirmed by EDAX when we used distilled water as a solvent (Michira *et al*. 2014). A very high amount of carbon was detected after adding the Green Tea extract. Especially in the samples 1, 2 and 3 the value of carbon is higher than other samples due to the stirring by using the magnetic stirrer at 70 ^{o}C. In Sample 4, the percentage of oxygen is higher than other thin films due to the polluted water. It can be clearly seen from EDAX analysis that all the thin films are having a very high amount of carbon content.

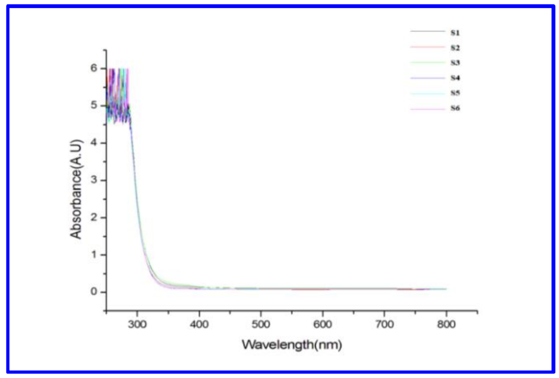

Fig. 2: Comparison of UV-Vis Absorption spectra of all the samples

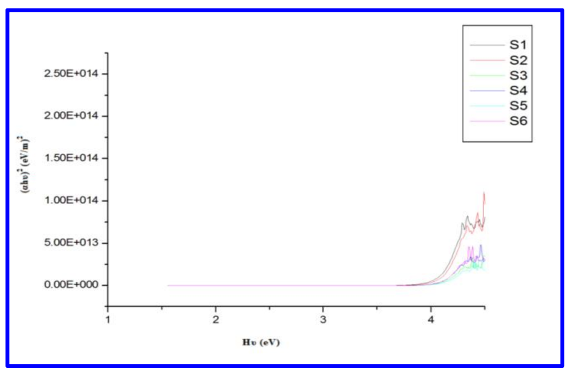

Fig. 3: Energy band gap of all the thin film samples

Table 1. Packing factor, micro strain and dislocation density

Sample	Inter planar Spacing(d)(Å)	Film Thickness (mm)	Atomic Packing Factor (P=D/d)	Micro strain (ε=β/tanθ)	Dislocation Density (δ=1/D^2)× 10^{14}lines/m^2	Grain size (D) (nm)
1	2.82	5.6	1.271	1.387	0.0777	0.358
2	3.5	5.9	0.792	2.270	0.135	0.275
3	2.03	10.5	1.836	0.963	0.071	0.372
4	1.535	8.9	1.998	0.883	0.106	0.306
5	3.618	11.2	0.983	1.571	0.078	0.355
6	1.347	11.9	3.121	0.565	0.056	0.420

Table 2. Results of Optical Studies

Parameters	Sample-1	Sample-2	Sample-3	Sample-4	Sample-5	Sample-6
Reflectance **R =1-(T+A)**	0.464	0.546	0.518	0.518	0.464	0.354
Absorption coefficient **α =(2.303× A)/d**	204651.84	142334.69	81426.68	67934.46	70275.01	63838.50
Refractive Index $\eta=\frac{[1-\sqrt{R}]}{[1+\sqrt{R}]}$	1.126	1.112	1.122	1.096	1.107	1.090
Extinction Coefficient **k = αλ/4π**	3.259	2.090	1.026	1.600	1.243	8.513
Dielectric Constant $\varepsilon'=n^2-k^2$	1.296	1.271	1.339	1.241	1.248	1.217
Imaginary Dielectric Constant $\varepsilon''=2nk$	8.572	8.564	3.425	5.313	4.172	2.232
Band Gap $\alpha h\nu= (h\nu -E_g)^n A$	3.90	3.92	3.95	3.98	4.01	3.91

Table 3. Comparison of EDAX results of all the thin films samples

Samples	C	O	Na	Mg	Al	Cl	K	Ca	P
S1	55.32	29.99	11.00	0.57	-	3.12	-	-	-
S2	51.73	38.02	4.87	1.01	-	2.05	1.97	-	0.35
S3	58.35	39.27	1.70	0.45	-	-	0.17	-	0.05
S4	20.00	56.85	15.29	4.11	-	1.85	-	1.90	-
S5	49.21	38.65	6.93	1.21	-	2.93	1.06	-	-
S6	54.07	37.29	5.01	1.22	0.33	0.83	0.75	0.51	-

3.4 Photoluminescence (PL) Study

One of the interesting aspects of the photo-physical properties is the photoluminescence (PL) of GTE thin film. The PL property is influenced by the structure, composition, particle size and morphology of the GTE thin film. In addition, the method of preparation has marked influence. Fig. 4 shows the comparison of PL spectra of GTE film. In the present work, the entire thin films exhibit a PL peak centered at nearly 485 nm. It is suggested that the emission peak at 485 nm is attributed to the transition from conduction band to valance band and the emission peak showed a blue shifts due to the quantum confined effect.

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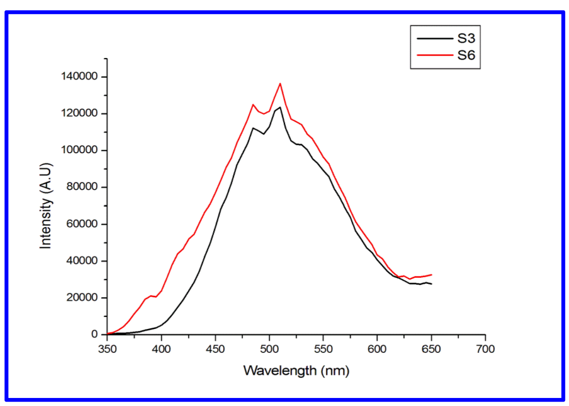

Fig. 4: Comparison of PL Spectra of GTE Film

4. CONCLUSION

Synthesis and characterisation of thin films from plant extract in varying sizes using Green Tea, *Tanner's cassia, Nerium oleander* and *Basil leaf* extracts were investigated. The extracts were deposited by using dip coating method at 70 °C on glass substrates. The structural and optical properties of the samples were investigated by using XRD and UV-Vis absorption spectroscopy. Thickness of the thin films was measured by Gravimetric method. Grain size of each sample was determined from the corresponding XRD pattern. It was found that the Grain size is more or less same when GTE is mixed with either pure distilled water or polluted water. Especially, when we used polluted water as a solvent, the grain size and packing factor were drastically increased. When packing factor is increased, the dislocation density and micro strain were decreased. Optical properties of all the samples were studied from the absorption spectra in the wavelength region 200 nm to 800 nm using UV-VIS spectrophotometer. Optical band gap of all the prepared thin films were estimated to be 3.9 to 4.0 eV. When the grain size increased, energy gap was decreased. All the samples have attained nearly 99% of transmission. It can be concluded that all the coated samples attained lower absorption and also contained 99% transmittance property. Due to the higher transmittance property, the prepared thin film has a great potential to prevent UV light. It is anticipated that the plant extraction with this composition can be used as a paint additives in order to maintain the colour of the paint for a long period owing to their good optical properties.

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